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(19)(CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Air Separator

(72) Tyler, Mike W. - U.S.A. ;
Whitson, Franklin E. - U.S.A. ;
Fett, Gerald C. - U.S.A. ;
Coleman, David B. - U.S.A. ;

(73) Griffin & Company - U.S.A. ;

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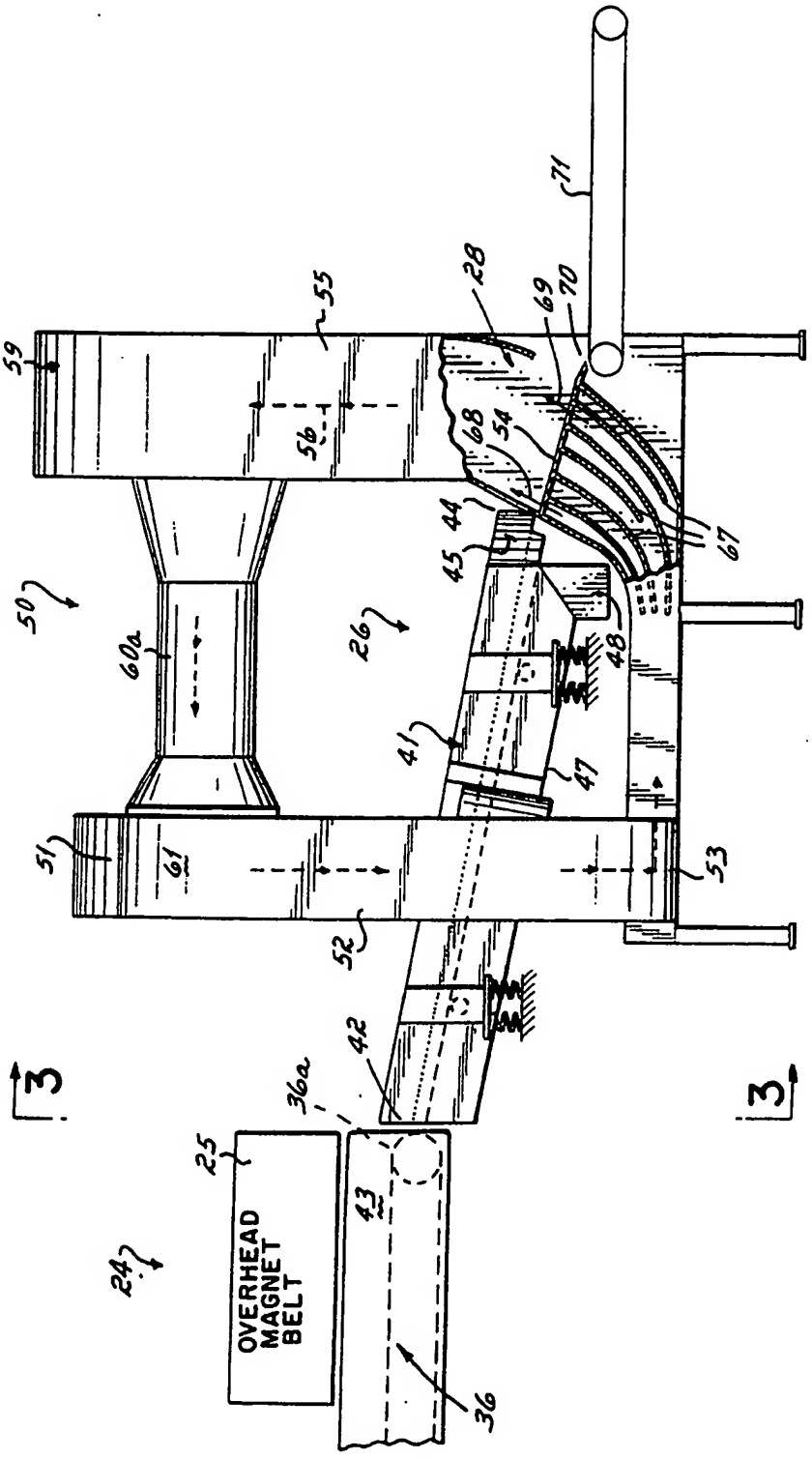
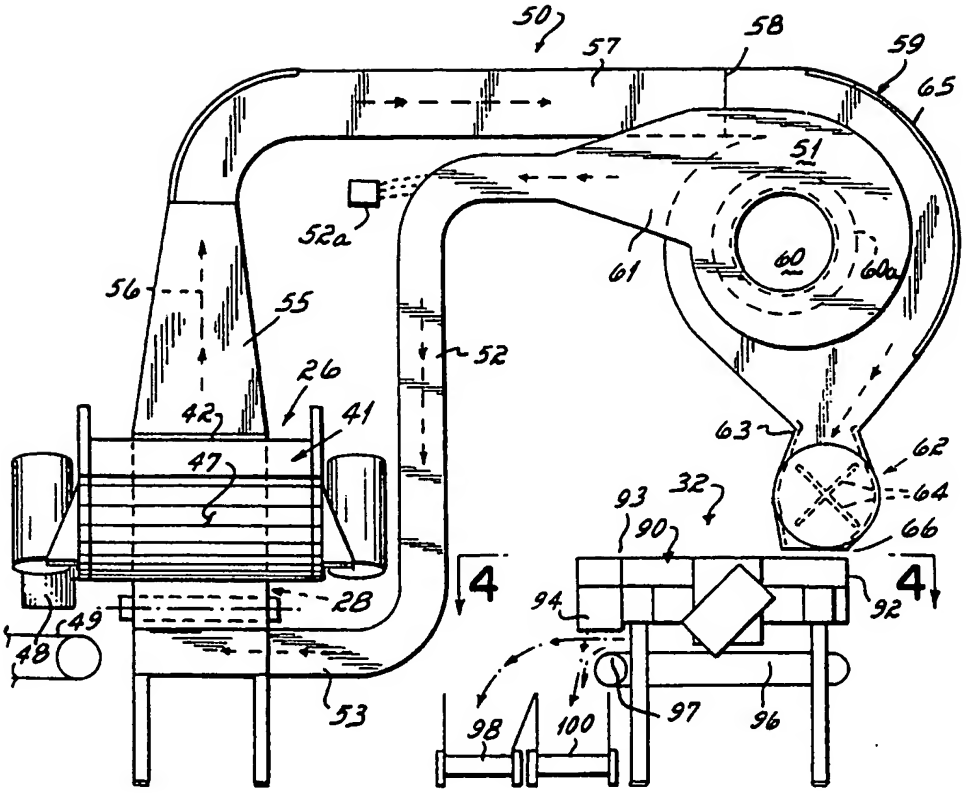


FIG.2


50
57
58
59
65
51
52a
61
60
60a
56
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52
26
42
41
47
63
62
64
66
93
32
90
4
4
94
92
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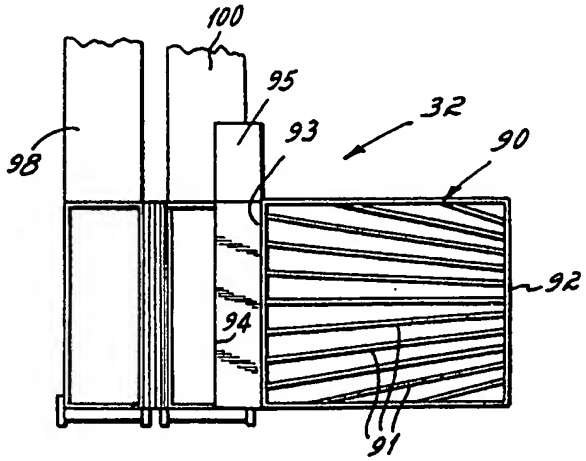
49
48
53
98
100
97
96

FIG. 3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93
32
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94
91

FIG. 4

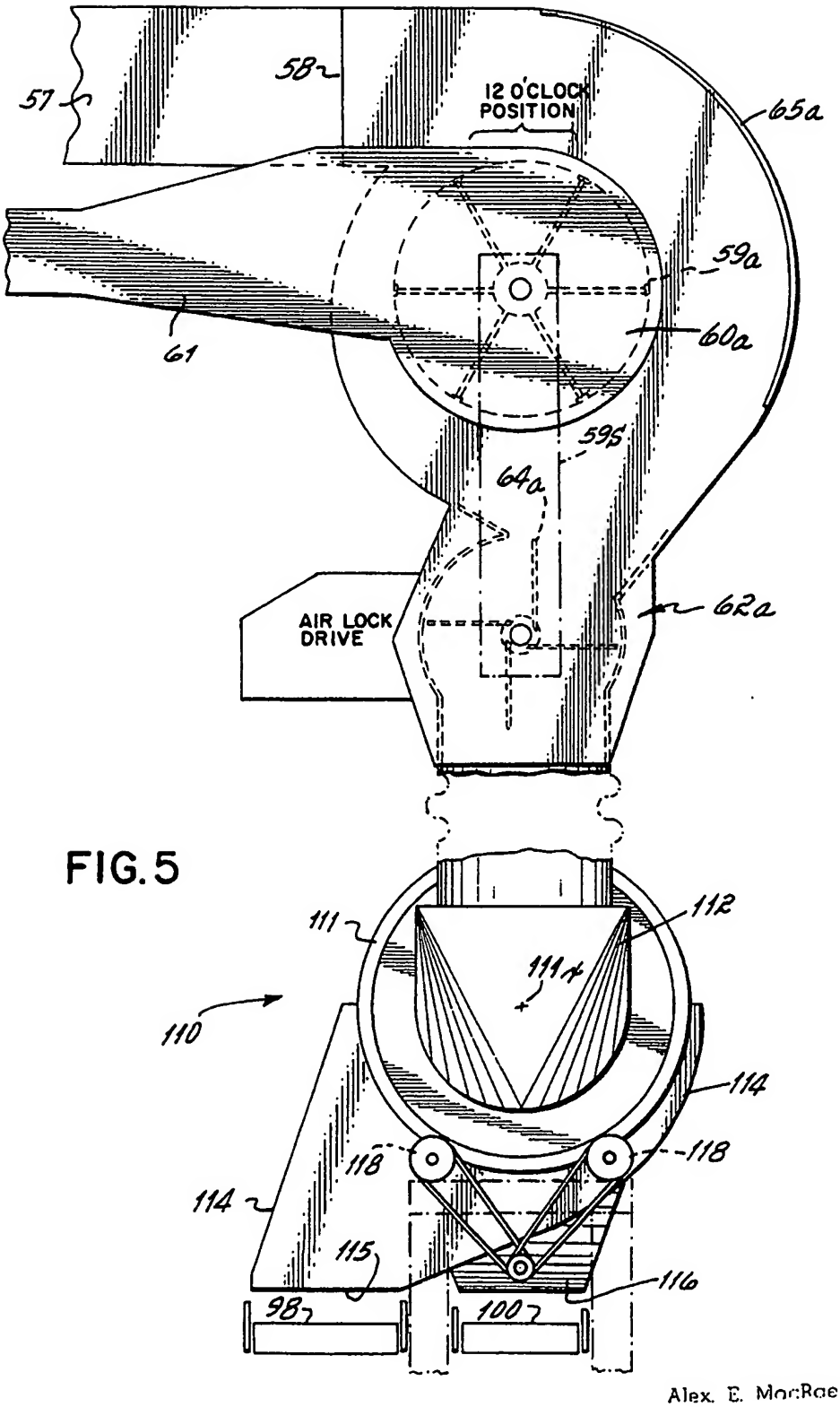
57
58
12 O'CLOCK POSITION
65a
59a
60a
61
59b
64a
AIR LOCK DRIVE
62a
111
112
111A
110
114
118
118
114
115
116
98
100

FIG. 5

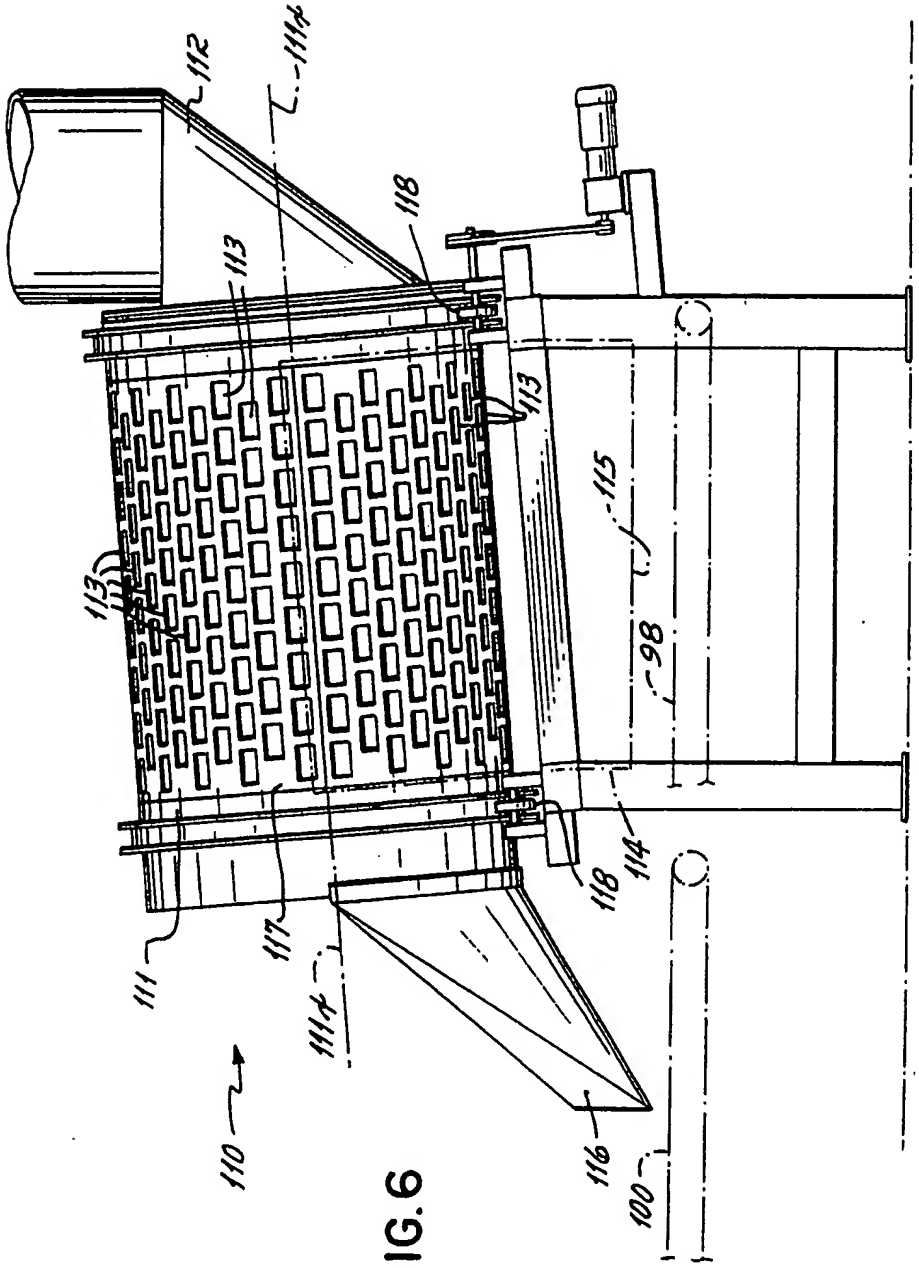

FIG.6

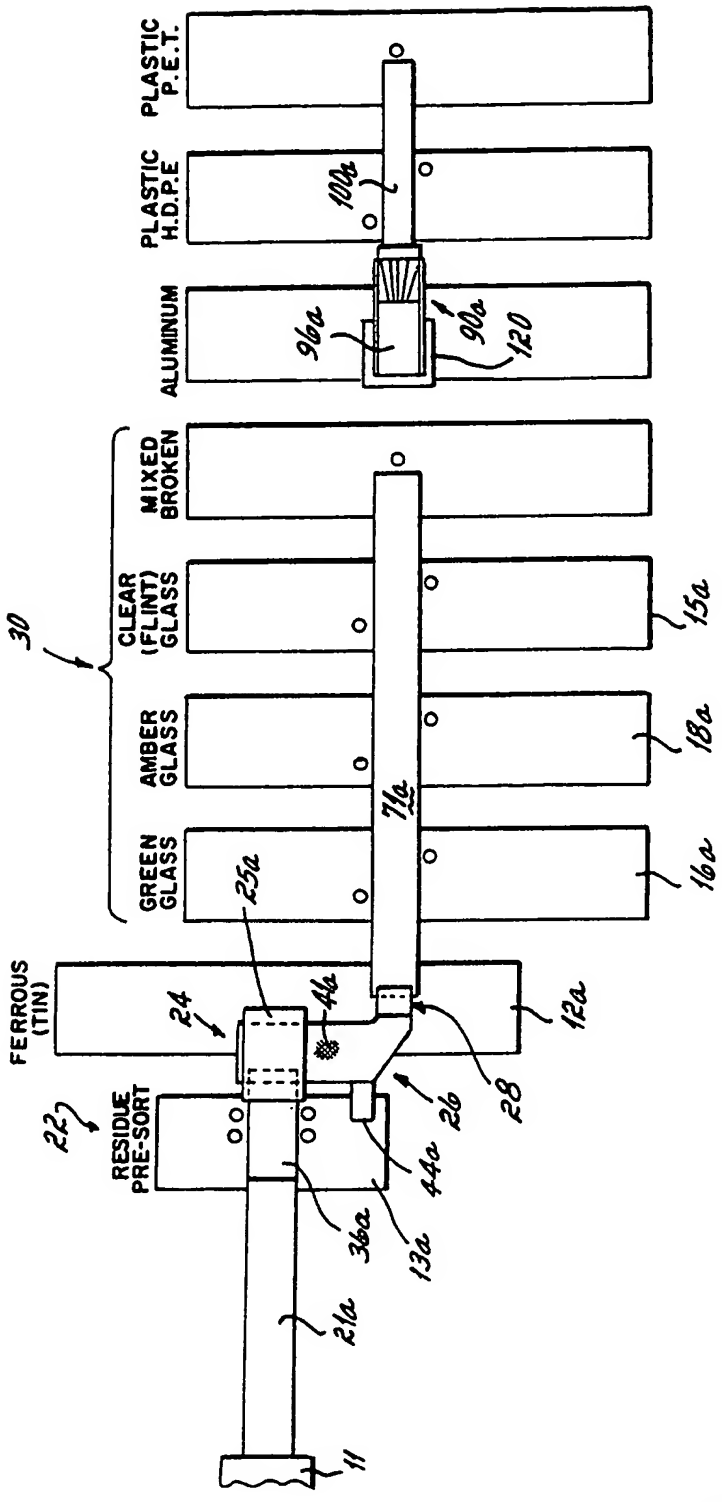
PLASTIC P.E.T.
PLASTIC H.D.P.E
ALUMINUM
MIXED BROKEN
CLEAR (FLINT) GLASS
AMBER GLASS
GREEN GLASS
FERROUS (TIN)
RESIDUE PRE-SORT
30
22
24
25a
46a
71a
15a
18a
16a
12a
26
28
44a
36a
13a
21a
11
96a
90a
120
100a

FIG. 7

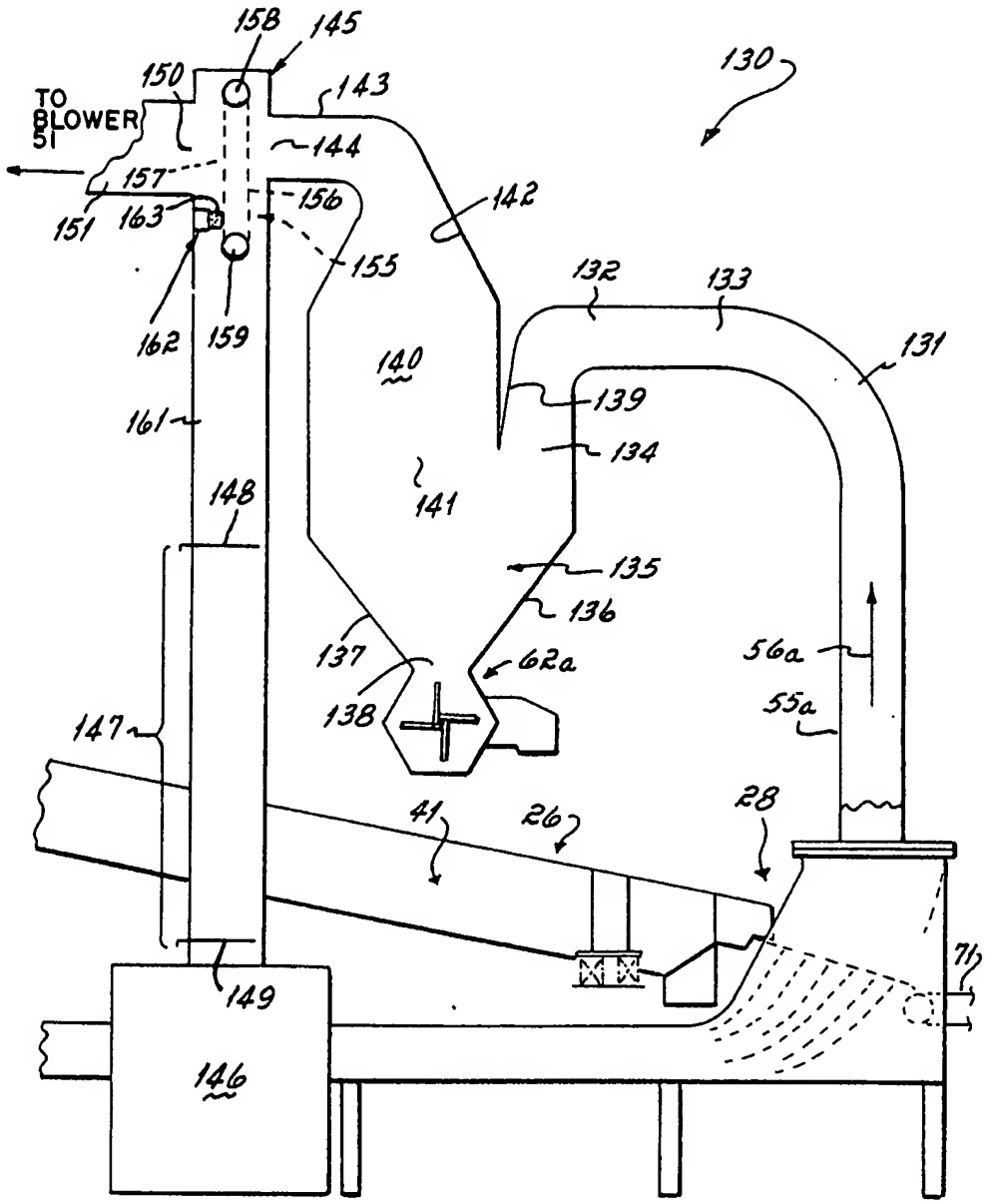
TO BLOWER 51
158
145
150
143
130
144
157
142
151
163
156
155
132
133
131
162
159
140
139
161
134
141
148
135
136
137
62a
56a
138
55a
147
41
26
28
71
149
146

FIG.8

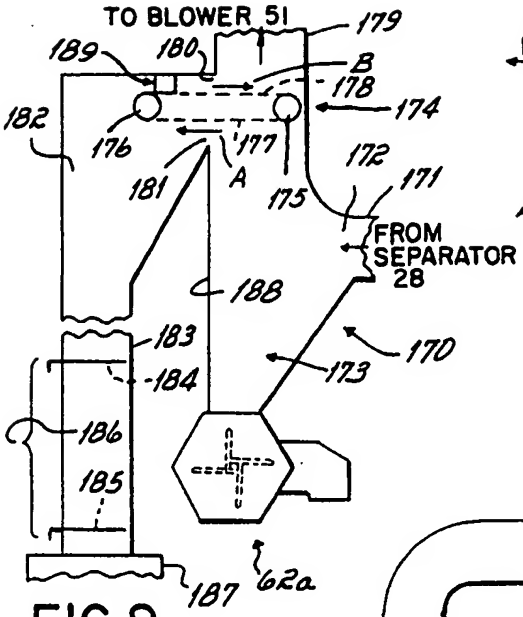

FIG. 9

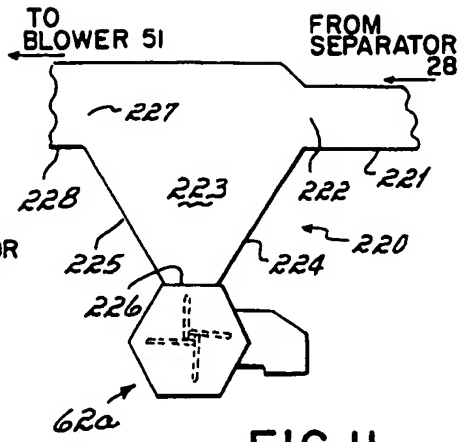

FIG. 11

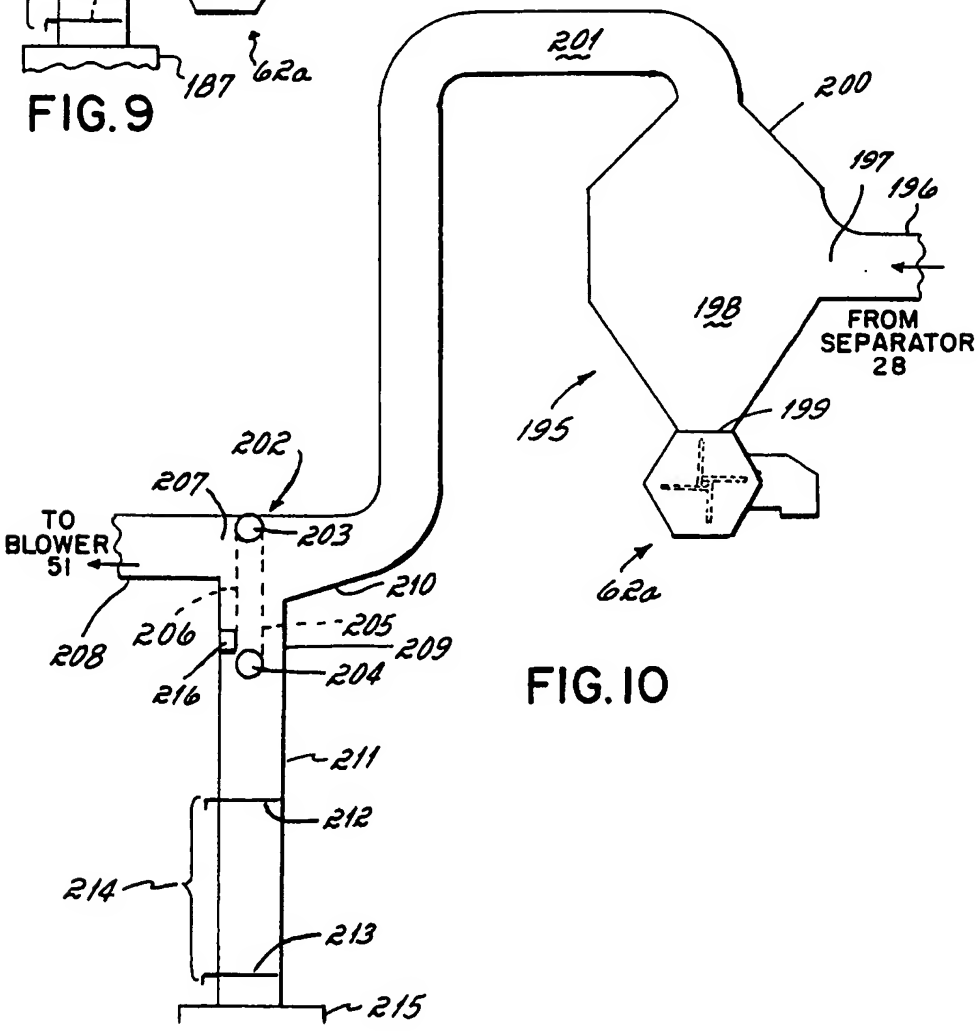

FIG. 10

This invention relates to waste recycling and apparatus and processes for separating ferrous, glass, plastic and aluminum articles from a commingled stream of such articles. More particularly, this invention relates to the separation of commingled plastic and aluminum articles from an air stream conveying such articles.

Many recycling projects are now underway across the United States as a way of protecting the environment from excessive waste disposal. Such processes generally involve the separation and collection of waste articles of similar materials at a "MRF" or Material Recovery Facility, and their recycling with similar materials into new goods.

In general, waste products of the type here considered are those made of ferrous, glass, plastic and aluminum. These include for example, steel and tin cans;

amber, green and clear (or flint) glass; plastic bottles, jugs and containers and aluminum cans.

While various existing projects involve individual persons separating various articles into separate containers at the point the articles are used, a major difficulty is currently presented by the desire to separate and collect such components from huge agglomerations of non-separated or commingled waste products. It has been highly desirable to provide a process by which the various components of such agglomerations can be efficiently separated and collected at flow rates and costs which render such processes economically feasible.

In the past, separation of such agglomerated components has been achieved by time consuming, expensive methods. For example, separation has been done manually, a process which is far too time-consuming and costly. In another method, a stream of commingled articles has been dropped through the air while air streams are directed across the articles to blow the lighter ones away from the heavier falling articles, much in the same manner as the biblical process of removing chaff from wheat by casting the mix to the winds. In still another process, heavy chains were drug across a commingled stream of articles to drag off the lighter plastic and aluminum articles from the heavier glass and metal. All these processes are either very expensive and/or do not provide the separation flow-through rates desired. Still other processes have not been entirely satisfactory or sufficiently cost efficient.

Many forms of apparatus and processes have been used in the past to classify finer or lighter from heavier particles or materials in other industries. Such other apparatus and processes are not believed suitable for separation of ferrous, glass, plastic and aluminum articles. One such prior device is the pneumatic tobacco classifier shown in U.S. Patent No. 4,915,824. In such device, intermixed light leaf and heavier stem tobacco particles are cast across a chamber in an arc-shaped projected stream. Air streams of varying velocities are directed against the stream to separate the lights from heavier particles. The heavier particles fall into a discharge chute across the chamber, while the lights are carried by the air to a centrifugal separator and are discharged through an air lock.

Such apparatus has worked well for tobacco particles but would not be suitable for separating ferrous, glass, plastic and aluminum articles of the sizes and weights normally encountered in an agglomeration of waste materials which must be separated for recycling. Projection of a commingled stream of such articles would cause breakage of the glass, and it is not apparent that certain components could be separated from others in such a system. Also, agglomerations of recyclable waste materials typically include undesirable residue materials in a vast array of sizes and weights. Such residue materials must also be separated from the ferrous, glass, plastic and aluminum articles. Thus, apparatus for separation of other products

is not helpful to or suggestive of apparatus or methods for handling recyclable articles of the type noted.

In the prior patent application, new apparatus and methods were disclosed for separating ferrous, glass, plastic and aluminum articles from a commingled stream of such agglomerated articles. A portion of that apparatus operated to separate lighter aluminum and plastic articles from heavier glass articles by means of a closed-loop air stream. These aluminum and plastic articles were then separated out of the air stream loop in a separator for further separation, while the purged air stream was directed back to a blower inlet. It is now desirable to provide separators of even more efficiency for separating the lifted plastic and aluminum articles from the closed loop air stream.

Accordingly, it has been one objective of this invention to provide improved apparatus and methods for use in separating ferrous, glass, plastic and aluminum articles from a commingled stream of such agglomerated articles.

A further objective of this invention has been to provide improved apparatus and methods for use in separating aluminum and plastic articles from glass articles, all of which are presented in a commingled stream of articles.

A further objective of the invention has been to provide improved separator apparatus and methods for separating recyclable waste articles entrained in an air stream from that air stream so the air stream can be reused.

To these ends, a preferred embodiment of the invention of this application is useful together with apparatus for receiving a commingled stream of ferrous, glass, plastic, aluminum and undefined residue articles, and for conveying such commingled stream of articles through progressive separation stations for respectively separating pluralities of the same kind of articles from the stream so that different kinds of articles can be separately collected. Such a commingled stream includes, for example, the following components:

Ferrous - steel and tin cans

Plastics - High density polyethylene (H.D.P.E.) such as milk jugs;
Polyethylene terephthalate (P.E.T.) such as 1 and 2 liter beverage containers;
and other plastic articles, i.e. liquid detergent containers, etc.

Glass - Amber, clear (or flint) and green glass articles;

Residue - Possibly foreign materials such as dirt, paper, plastic bags etc.

The commingled stream is first conveyed past individual operators for manual residue removal and then past a magnetic separator which removes ferrous materials. From there the stream is expanded on a vibratory screen for removal of further residue articles and smaller or mixed broken glass pieces. The remaining commingled stream of

glass, plastic and aluminum articles is then concentrated by a narrowing section of screen conveyor and introduced to a porous surface conveyor extending across a perpendicularly moving, upward flowing portion of air traveling in a closed loop system. The air column lifts lighter plastic and aluminum articles from glass articles in the stream; the glass being conveyed beyond the closed loop column where its components are further separated and collected.

The lifted plastic and aluminum articles travel in the air column within the closed loop to a separator, preferably such as the improved separator disclosed herein, where they are separated from the air stream loop. The improved separator is particularly useful where the stream at this point includes light foreign articles such as plastic bags which the screening separator prevents from traveling to the fan. The cleared air flow is directed back to a fan intake from where it is continuously directed onto the moving commingled stream.

A portion of the air flow is removed or taken off via a dust skimmer which serves two purposes; one to maintain a negative pressure in the closed loop system and another to skim off dust particles present in the air stream, thus maintaining a clean air stream.

The discharged plastic and aluminum article stream at this point comprises primarily large and small plastic articles and aluminum. These are separated in two phases. First, the larger plastic articles are separated from the stream by conveying the stream over a plurality of bars

which are spaced to allow the smaller plastic articles and aluminum to drop away from the larger plastic articles. These larger articles are conveyed away from the remaining commingled stream.

Such plastic and aluminum are alternately separated at this point by using a trommel which screens or passes the aluminum cans, but not the plastic (other than very small plastic articles). The resulting aluminum and any small plastic articles can be further separated by an eddy current separator as mentioned below.

A stream of smaller plastic articles and aluminum is directed to the discharge end of a conveyor associated with an eddy current non-ferrous metal separator. The plastic articles drop off the end of the conveyor while the aluminum articles are kicked out in a flatter trajectory; the plastic and aluminum articles falling on respective adjacent parallel conveyors. The aluminum is collected, while the plastic articles are recombined with the larger plastic articles for respective collection after compaction. Perforation of the plastic, prior to compaction, can be performed if desired.

The closed loop air flow is particularly useful to separate plastic and aluminum articles from heavier glass articles. While the porous conveyor surface is of sufficiently large area to handle significant stream flow, the ascending air column is progressively confined to increase velocity, without undue power drain, to effectively remove and convey plastic and aluminum articles while leaving

heavier glass. Use of the centrifugal or screen separator and closed loop air flow facilitates operation, reduces effluent, which may contain dust, and facilitates separation at sufficiently low cost.

The porous surface at the air lift or separation station is slightly inclined downwardly from upstream to downstream ends, while the drop to it from the introducing vibrating screen, and the drop to the glass discharge conveyor from the porous plate are minimized to reduce glass breakage.

If desired, the air flow moving upwardly across the commingled stream can be divided into a plurality of air streams, each directed across the commingled stream. A first higher velocity air flow stream contacts the commingled article stream prior to contact thereof by lower velocity air flow streams. All such air flow streams combine in upper portions of the air column for entraining and conveying lifted plastic and aluminum articles.

Flow rates already attained by the invention have reached, for example, 10 to 15 tons per hour with a closed loop air flow about 3 feet across at interface with the commingled stream. For this result, an air flow of about 21,000 cfm is used across the commingled stream at a velocity of about 2100-2300 fpm. The parameters are suitable to separate constituents of the stream including heavier plastic articles like liquid detergent bottles. An air flow of about 18,000 cfm is used at a velocity of about 1800-2000

fpm when such heavier plastic articles are not anticipated in the stream.

A preferred embodiment of the improved separator for separating the lifted plastic and aluminum articles from the closed loop air stream includes an enlarged chamber receiving the entrained articles from a restricted conduit in which the articles are conveyed at about 4500 fpm. The enlarged chamber produces a drop in the velocity of the air stream and entrained articles and the articles drop out of the air stream for discharge, preferably through an air lock.

The air stream is directed onto a moving porous conveyor, which it penetrates, and moves on to the fan or blower inlet, completing the closed loop. Any lighter articles, such as paper, plastic bags, etc. which did not drop out of the air stream are stopped by the porous conveyor. They are moved in a direction transversely away from the stream and are discharged into a still air column or receptacle, preferably through another air lock. A scraper is preferably provided on the return run of the porous conveyor for removing any remaining residue.

In this way, the air stream is efficiently purged of plastic and aluminum articles it separated from the glass and heavier articles, and as well is efficiently purged of lighter articles such as paper and lightweight plastic film or bags.

It will thus be appreciated that the invention provides improved apparatus and methods for separating

ferrous, glass, plastic and aluminum articles from each other for separate collection and subsequent recycling, and improved apparatus and methods for separating lifted aluminum and plastic articles and residue from the closed loop air stream. Further advantages, details and modifications will be readily apparent from the following detailed description of a preferred embodiment and from the drawings in which:

Fig. 1 is a diagrammatic plan view or flowchart illustrating the invention;

Fig. 2 is an elevational view taken along lines 2-2 of Fig. 1 and showing further detail of the apparatus thereof;

Fig. 3 is an elevational view taken along lines 3-3 of Fig. 2;

Fig. 4 is a plan view taken along lines 4-4 of Fig. 3;

Fig. 5 is an elevational view similar to a portion of Fig. 3, but illustrating diagrammatically features of a rotating screen separator and an associated "trommel";

Fig. 6 is an elevational side view of the "trommel" of Fig. 5;

Fig. 7 is a diagrammatic plan view of an alternative layout of the invention incorporating a closed loop separator, parts thereof omitted for clarity;

Fig. 8 is a view similar to Fig. 2 but showing features of a preferred improved air screen separator; and

Figs. 9-11 are illustrative elevational views of further alternative embodiments of an improved air screen separator.

SYSTEM LAYOUT

Turning now to the drawings, a diagrammatic plan view of the preferred embodiment of the invention in Fig. 1 illustrates a complete system for receiving a commingled stream of varying components and for separating and collecting those components. The system 10 receives a commingled stream of various recyclable ferrous, glass, plastic and aluminum articles as described above in the summary of the invention, onto conveyor 11 and is operable to separate the components and collect like components in large "roll-off" containers, such as 40 cubic yard roll-off containers which can be used to transport the articles to recycling facilities. These containers are illustrated at 12-19. As will be mentioned, container 13 is optional.

Alternately, the separated ferrous, aluminum and plastic constituents are baled and are discharged for transfer to recycling facilities.

Container 12 is positioned for receiving ferrous articles separated by the system 10. Optional roll-off container 13 is positioned for receiving residue materials ejected from the system. Roll-off container 14 is located to receive aluminum articles. Container 15 is oriented to receive clear (or flint) glass articles. Container 16 is oriented to receive green glass articles. Container 17 is oriented to also receive residue materials. Container 18 is

oriented to receive amber glass materials or articles. Container 19 is oriented to receive plastic articles.

The articles making up the commingled stream generally include ferrous material such as steel and tin cans, a plurality of different glass articles, such as clear (or flint), green or amber glass, various ones of which are used for example, in various beverage and other containers, plastic articles such as high density polyethylene and polyethylene terephthalate articles such as found in milk jugs, soft drink containers and the like, and other plastic articles such as liquid detergent bottles, and aluminum articles, such as aluminum cans, together with an residue materials which have found their way into the agglomeration of the mixed articles. It will be appreciated that this indiscriminate mixture of articles is retrieved from collection points and can be dumped, for example, on a receiving floor 20. The articles from there are loaded, such as by a Bobcat loader, receiving and delivery chute or other means, onto the receiving conveyor 11.

Receiving conveyor 11 is preferably a chain conveyor, for example, and is positioned for receiving, as noted above, the commingled agglomeration of articles and for conveying them in a commingled stream into the system 10. Other devices and systems for feeding a commingled stream onto conveyor 11 could be utilized and it will be appreciated, for example, that partially separated articles could also be introduced to conveyor 11 for further classification or separation.

From the receiving or loading conveyor 11, the commingled stream of articles is transferred to an in-line conveyor 21 which serves to transport the articles from the receiving area to a first manual sort station 22 when foreign or residue articles are manually removed. From there, the remaining commingled stream is transferred to a ferrous removal station 24 for removing articles containing ferrous material. The remaining stream is then transferred to a screening station 26, at which point the remaining commingled stream comprises generally glass, plastic and aluminum articles. Further residue is removed therefrom by passing through a screen at station 26. From the screening station 26, the remaining commingled stream is introduced to a closed loop air flow station 28 for removing plastic and aluminum articles from glass articles. The glass is conveyed from station 28 to a glass sort station 30 while the remaining combined plastic and aluminum articles are lifted away from glass at station 28, in the closed loop system, and transferred to a plastic and aluminum separation station 32.

SYSTEM DETAILS

Returning now to the in-line conveyor 21 in Fig. 1, further details of the various separating apparatus and methods will now be described. As noted, the commingled stream is conveyed by conveyor 21 to a first sort station 22. First sort station 22 includes a generally horizontal belt or other type conveyor 36, receiving the commingled stream from conveyor 21. A plurality of individual

operators, indicated at 37, are positioned near the conveyor 36, so that as the commingled stream passes, they can manually remove undesirable residue materials and place them on the residue conveyor 40. That conveyor 40 extends from the left- to the right-hand side of Fig. 1 for conveying and depositing residue materials into the residue roll-off container 17.

Conveyor 36 carries the commingled stream beneath a magnetic ferrous article removal station 24. This station includes an overhead magnetic belt apparatus 25 with, for example, a 5 horsepower drive, and can be of any suitable type. One suitable such unit, for example, is model number SE 7725, purchased from the Eriez Company of Erie, Pennsylvania. The magnetic belt of the ferrous removal station 24 moves in a direction transverse to the machine direction of the belt conveyor 36. When current is applied, the apparatus 25 attracts ferrous material in the combined stream upwardly and away from the remaining articles on conveyor 36. The ferrous articles are then transferred through a baler 38 which flattens and compresses the articles into a bale. The bales may then be discharged onto a conveyor 39 for transfer into the roll-off container 12 for steel articles, or simply discharged for loading or transfer to further ferrous recycling facilities. Any suitable ferrous article baler can be used.

After passing the ferrous removal station 24, the combined stream is conveyed to the discharge end 36a of the conveyor 36 and deposited onto a vibrating screen conveyor

41, defining the screening station 26. Screen conveyor 41 has an upstream end 42, which is wider than the discharge end 44. When the combined stream is discharged from the discharge end 36a onto the screen 41, the stream of articles is no longer confined between the conveyor walls 43, for example, of conveyor 36. The stream thus expands outwardly and transversely across the screen 41. At the same time, the screen 41 is driven by a vibrating mechanism for conveying the remainder of the combined stream, still including glass, plastic and aluminum articles, from the upstream end 42 to the downstream end 44 thereof. The vibrating screen conveyor is model number VS-60144 manufactured by Griffin & Company of Louisville, Kentucky, and includes mesh openings of about 2 inch squares for permitting further residue and undesirable articles to fall therethrough.

It will be noted that the downstream end 44 of screen 41 is quite a bit narrower than the upstream end 42 of the vibrating screen conveyor 41. Thus, as the combined stream moves from the upstream end 42 to the downstream end 44, it is first expanded (from conveyor 36) and then concentrated by the tapering guides 45 and 46, at the downstream end 44, for introduction to the closed air loop separation station 28, as will be further described.

The vibrating screen apparatus 41 includes a bottom plate 47. When residue material falls through the screen, it lands on the plate 47 and is conveyed to a discharge chute 48, from where it is introduced to a discharge conveyor 49 for transfer to the optional roll-off

residue container 13. It will be appreciated that the roll-off residue container 13 is optional and can be eliminated. For example, if the stream is guaranteed free of residue, if residue is otherwise removed, or if residue is deposited directly on conveyor 40, container 13 will not be needed. The chute 48, for example, could simply be extended to deposit residue on the adjacent residue conveyor 40 for ultimate deposit in the residue roll-off container 17.

From the discharge end 44 of vibrating screen 41, the commingled stream, still including glass, plastic and aluminum articles, is introduced to a closed air loop separation station 28, where the aluminum and plastic articles are lifted from the glass articles and carried away by a moving column of air. Thereafter, the glass articles are conveyed away from station 28 for further sortation and classification, while the combined stream of plastic and aluminum articles are also conveyed by the air to a discharge from the closed air loop for further separation.

Perhaps the details of the closed loop air separation apparatus are best seen in Figs. 2 and 3. In Fig. 2, it will be appreciated that the commingled stream has been discharged from conveyor 36, across screen 41 at discharge end 44 into the station 28.

Station 28 is defined, in part, by a closed loop air separator 50. Essentially, the combined stream is conveyed through the station 28 and a closed loop of moving air, a portion of which defines an upwardly air flow or column, is directed from beneath the combined stream,

through it and upwardly to lift off the lighter plastic and aluminum articles from the glass articles. The combined plastic and aluminum articles are then entrained in the air flow and conveyed to a rotary screen separator or a centrifugal classifier where the aluminum and plastic articles are discharged through an air lock and the air returns to the blower intake for further upward impingement on the moving commingled stream, all in a closed loop configuration.

The closed loop separator 50 thus includes a blower 51, and a duct 52 connected from an exhaust of the blower to a horizontal duct 53 at a lower end thereof. Duct 53 extends beneath an inclined, commingled stream receiving perforated plate 54. Discharge end 44 of screen 41 and plate 54 are disposed to minimize the drop of the stream to the plate.

A dust skimmer diagrammatically indicated at 52a (Fig. 3) is provided for venting a portion of the air to maintain a negative pressure in the loop and to remove dust from the air loop.

Air exhausting from the blower is conducted through the duct 52 to the duct 53 and from there upwardly through the perforated plate 54 into the tapered or converging duct 55, defining an upwardly moving air column 56. Duct 55 is connected to an upper horizontal duct 57, which is attached to the inlet end 58 of a separator 59. Separator 59 has an internal exhaust area 60, which is adapted for connection through duct 60a to blower 51. From the blower

outlet the air moves to the inlet end 61 of the duct 52 for return to station 28.

A rotatable vane air lock 62 is connected to the lower end 63 of the separator 59. Air lock 62 is generally cylindrical in shape, as shown in Fig. 3, and is provided with a series of rotatable vanes 64.

ROTATING SCREEN SEPARATOR

Separator 59 can be a simple centrifugal separator (Fig. 3), but preferably a rotating screen separator (such as shown in the top portion of Fig. 5) is used. Such a separator includes a rotatably mounted cylindrical screen 59a driven by a slave drive 59s from the rotatable air lock 62a having a plurality of rotatable vanes 64a.

Screen speed is not generally sufficient to throw off articles held thereon by air. However, as the screen 59a rotates, articles at the 12 o'clock position (Fig. 5) are hit and wiped off the screen by incoming articles entrained in the air stream in duct 57. Air exits through the screen into duct 60a which feeds an input of blower 51, as noted above.

Alternately, as plastic and aluminum articles are received in a centrifugal separator 59 (Fig. 3), they engage the back wall 65 thereof and drop out into the air lock 62. From there the rotating vanes 64 progressively drop the combined plastic and aluminum articles through discharge end 66 while maintaining an essentially sealed outlet from the separator.

CLOSED LOOP SEPARATION

Accordingly, it will be appreciated that a closed loop separator 50 generates and defines a closed loop of air, and more particularly in at least one portion, an upwardly moving column of air. That column arises, from beneath the commingled moving stream of articles, up through a porous plate supporting such articles, to lift and carry off lighter aluminum and plastic articles from heavier glass articles at station 28. The lifted articles are introduced to a separator 59 for discharge while the air column is separated from the articles at the separator 59 and is returned to the blower inlet, providing a closed loop of air flow.

The blower or some other portion of the closed loop system includes an adjustable exhaust, and appropriate dust filter or skimmer 52a, for bleeding off air as described above. More particularly, it will be appreciated that it is desirable to maintain at least a slight negative pressure within the closed loop system of the closed loop separator 50. In that regard, it will be appreciated that the air velocities remain relatively high, while the pressures are kept relatively low in order to provide the negative pressure differential with respect to the pressure inside the system and the ambient pressure outside the system, so as to reduce leakage from inside to outside the system.

As an example, the velocity of the air impinged on the commingled stream on the porous surface 54 is approximately 1800-2300 feet per minute, which is sufficient to

lift aluminum and plastic articles of the type found in many recycling systems, such as aluminum cans, plastic bottles and jugs. The air velocity of approximately 1800-2300 feet per minute translates to a closed moving air loop, wherein the air velocities along the loop somewhat differ, for example, from about 1500 feet per minute at the blower inlet, to about 2600 feet per minute at the inlet station 28 just beneath the porous plate 54. These ranges provide sufficient velocity and air flow in the vertical lift portion of the loop to effectively separate the constituents anticipated in the stream as described herein. Thus, while there may be a positive pressure at the fan discharge, the downstream pressure through the system falls to a negative pressure with respect to the outside air. The aforementioned bleed off, for example, may amount to about ten percent (10%), in conjunction with this operation, providing the negative internal pressure desired.

More specifically, an air flow of about 18,000 cfm with a commingled stream contacting velocity of about 1800-2000 fpm is sufficient to separate aluminum and plastic articles from glass where heavier plastic articles such as plastic liquid detergent bottles are not contemplated. When they are included, a flow of about 20,000 cfm at stream contacting velocities of about 2000-2300 fpm is preferable so these can be separated as well.

The closed air loop separator 50 differs from that separator described in U.S. Patent No. 4,915,824 in several significant respects. First, it will be appreciated that

the duct 55 defining the upwardly moving air column 56 is much narrower than that of the separator in the noted patent. In the separator in the noted patent, it will be appreciated that tobacco particles are projected, by means of vanes across the chamber within the separator. Varying air streams are impinged on the projected arc of particles to lift the lighter particles from the heavier ones. On the other hand, in the current separator, it will be appreciated that the commingled stream of glass, aluminum and plastic articles are discharged from the discharge end 44 of the vibrating screen onto the porous plate 54, where the articles slide along that plate to a discharge end 70 thereof. The remaining articles, primarily of glass at this point, are discharged onto a conveyor 71, which conveys the remaining glass to the various glass sort stations downstream. Accordingly, the articles to be separated are not projected across the closed loop, but are conveyed across the closed loop and the porous plate 54. Like the tobacco separator in the U.S. patent, the closed loop air flow is divided into a plurality of air streams, as shown in Fig. 2, by means of vanes 67 such that a first air stream 68 closer to the discharge end 44 of the screen 41 is of a faster velocity impinged across the commingled stream than a more downstream air stream portion 69 of the column moving upwardly and nearer the discharge end 70 of screen 54. However, it is believed that even a homogenious air stream moving upwardly through the plate 54 could be suitable.

Moreover, it will also be appreciated that porous plate 54 is only slightly inclined in the current invention, much less than the screen of the patent which is mounted at a much steeper angle. It is desirable to maintain the glass articles in the largest possible pieces. Having them slide down an incline at fast speeds can lead to more break up. Accordingly, the incline of plate 54 is determined to be small as reasonably possible to maintain gentle movement of the moving stream.

GLASS SEPARATION

Turning now to a further description of the glass separation feature of the system, the glass articles comprising all clear (flint), green and amber glass articles are discharged from the station 28 onto the conveyor 71 and conveyed to a plurality of manual glass sort stations 72 and 73. At stations 72, 73, individual operators pick up the various glass articles and direct them into an appropriate chute as shown in Fig. 1 at a number 74. As shown in Fig. 1, it will be appreciated that the conveyor 71 diverges into upper and lower (as seen in Fig. 1) conveyors 75 and 76, so that the combined glass streams can be broken down and expanded into two streams for efficiency of sorting. Respective chutes 74 are connected to various conveyors 77, 78 and 79 in a known fashion. Conveyor 77 receives clear (flint) glass articles from clear glass article chutes and deposits them onto a glass loading conveyor 80 for deposit into a clear (flint) glass roll-off 15. Conveyor 78 receives green glass articles from chutes receiving green

glass articles from the operators at stations 72, 73 and deposits the green glass articles onto a glass load conveyor 81 for conveying green glass articles into the roll-off container 16. Conveyor 79 receives amber glass articles from chutes into which amber glass articles are deposited and conveys amber glass articles to conveyor 82, which conveys the articles for loading into the amber glass roll-off container 18. It will be appreciated that each of the roll-offs 14, 15, 16 and 18, for example, are provided with diverting chutes or conveyors 84 through 87, as shown in Fig. 1, for spreading the articles received into the respective roll-off containers 14, 15, 16 and 18.

PLASTIC AND ALUMINUM SEPARATION

Returning now to station 28, it will be appreciated that aluminum and plastic articles have been lifted at that station to a separator 59, where they are discharged through the air lock 62 (or 62a) in a commingled stream of plastic and aluminum articles into plastic-aluminum separation station 32.

In one embodiment (Fig. 3) separation station 32 includes apparatus for first separating larger plastic articles from the combined stream of plastic and aluminum and thereafter means for separating the smaller remaining plastic articles from the aluminum. After the smaller plastic articles are separated from the aluminum, the larger and smaller plastic articles are recombined for compaction, optional piercing, and collection, and the aluminum articles are separately collected.

The station 32 thus in one embodiment (Fig. 3, 4) comprises apparatus known colloquially as a "grizzly scalper" 90, model number GS-3660, manufactured by Griffin & Company of Louisville, Kentucky. This scalper includes a vibratory conveyor having, as perhaps best seen in Fig. 4, a plurality of longitudinal bars 91, which are generally parallel, but slightly diverge from an upstream end 92 to the downstream end 93. As the combined aluminum and plastic are conveyed along these bars by means of vibration of the conveyor, all smaller aluminum and plastic articles fall therethrough while the larger plastic articles such as milk jugs and large beverage containers for example, remain on top of the bars and are conveyed onto a discharge end 94 and then transversely to a discharge chute 95.

Meanwhile, the aluminum and smaller plastic articles which fall through the bars 91, land on an eddy current non-ferrous metal separator conveyor 96, where they are conveyed toward a discharge end 97 thereof. The eddy current non-ferrous metal separator is manufactured by the Eriez Company of Erie, Pennsylvania, and is known as its model number ECS-24. This particular separator has means to repel the aluminum articles. Thus as the combined aluminum and plastic articles are conveyed toward the discharge end 97, the aluminum articles are cast outwardly as shown, where they land on a conveyor 98. From conveyor 98, the aluminum articles are conveyed to conveyor 99, where they are discharged by means of the diverting chute 84 into the aluminum

roll-off container 14, or to an appropriate baler of any suitable type.

The plastic articles, however, are not repelled by the non-ferrous metal separator and thus their trajectory is much shorter and they land on the closer conveyor 100. Conveyor 100 moves directly under the discharge chute 95 of the "grizzly scalper" 90, such that the larger plastic articles moving through the discharge chute 95 are discharged onto the conveyor 100 and are thus recombined with the smaller plastic articles, where they are conveyed to conveyor 101, for transfer to a compactor or baler 104 prior to discharge or loading into roll-off container 19. Any suitable compactor or baler such as baler model number HAL-7RP made by the Selco Baler Company, division of Harris Group of Baxley, Georgia. Optionally, the plastic articles can be first introduced to a plastic perforator 102, and from there to a compactor or baler 104. The plastic perforator 102 serves to punch holes in the various plastic articles so as to facilitate their compaction by releasing air, etc. which might be otherwise trapped therein.

ALTERNATIVE PLASTIC AND ALUMINUM SEPARATION

In another embodiment, as shown in Figs. 5 and 6, a "trommel" 110 is used to separate plastic from aluminum articles and discharge them respectively onto conveyors 98 (aluminum) and 100 (plastic). Such a trommel is effectively used in situations where the plastic and aluminum introduced to the trommel 110 include aluminum cans, many of which may have been pre-crushed, and larger plastic items such as

various forms of liquid containers. In many recycling programs the nature of the aluminum and plastic constituents can be predetermined to render this separating embodiment particularly efficient.

In this regard, trommel 110 inclines a cylindrical drum 111 mounted for rotation about a declining axis 111x.. An inlet chute 112 is positioned to receive plastic and aluminum articles from separator air lock 62 or 62a and deliver them to the internal area bounded by drum 111. Openings 113 in the drum surface are sized to pass the smaller aluminum articles, but not the larger plastic articles.

As drum 111 rotates, the aluminum articles move along the drum and fall through openings 113 onto chute 114 having a discharge outlet 115 laterally spaced from beneath the drum 111 and over aluminum conveyor 98. Another chute 116 is disposed to receive larger plastic articles, discharged from lower end 117 of drum 111, and to discharge the plastic onto plastic conveyor 100.

In this manner, plastic and aluminum are lifted from the stream at station 28 and separated at station 32 by means of a trommel 110. As noted, this embodiment is particularly useful when the aluminum and plastic constituency of the stream can be predetermined with consistency and where the size of the aluminum articles and the size of the plastic articles lend themselves to efficient separation by this means.

Of course, as diagrammatically shown in Figs. 5 and 6, the drum 111 can be mounted to ride on motor driven rollers 118 for rotation, or can be constructed or mounted in any suitable fashion.

GENERAL OPERATION

In one example of operation a commingled stream of ferrous glass, plastic and aluminum articles are deposited onto the receiving conveyor 11 and thereafter transferred by conveyor 21 into the system. Where the separator station 28 is approximately 3-4 feet wide and the air flows are as previously mentioned, such a system can be utilized to handle on the order of 10 to 15 tons per hour of commingled stream articles with the ferrous glass, plastic and aluminum articles all being separated in kind from each other by means of the apparatus at a very efficient flow rate.

Moreover, utilization of the apparatus as described provides very efficient article separation, with a minimization of other kind articles ending up in the respective collection points or roll-offs. Moreover, it will be appreciated that the closed loop separator 50 greatly facilitates the separation of aluminum and plastic articles, on the one hand, from glass articles on the other, without subjecting the glass articles to undue handling or breakage. In this regard, the discharge end 44 of the vibratory screen conveyor is located as closely as possible to porous plate 54, the discharge end 70 from the station 28 is oriented to make as gentle a transition as possible onto the conveyor 71, and plate 54 is inclined at only a minimum angle to

assure gentle article stream flow. In the meantime, the air flows and velocities are sufficient to lift the aluminum and plastic articles upwardly in upwardly moving air columns.

It will be appreciated that various portions of the system 10 could be eliminated or modified as suggested herein depending, for example, on the nature and content of the commingled stream of articles. For example, if residue articles and materials are eliminated, the initial manual sorters or operators are not necessary. Where certain plastic and aluminum constituents are predicted, the trommel separator described can be used in place of the "scalper" apparatus described.

It will also be appreciated the other variations of the invention could be used. For example, the air chamber or flow station 28 could be separated into two or more chambers and respective various stream constituents lifted and separated from each other by varying air velocities of separate closed air loop portions in each respective chamber. Such a variation may render further downstream separation of the lifted constituents unnecessary.

ALTERNATIVE SYSTEM LAYOUT

Moreover, other system layouts embodying the features described above, or modifications thereof can be used.

For example, Fig. 7 diagrammatically illustrates an efficient layout utilizing the foregoing principles. This system is also for handling a commingled stream as noted above and utilizes a manual sort station 22, a ferrous

removal station 24, a screening station 26, an aluminum/plastic lift or sort station 28, manual glass sort stations 30, and plastic and aluminum separation stations 32 functionally and essentially like those described above. These stations are numbered like those in Figs. 1-6 since similar sortation or separation functions are performed at each.

The layout in Fig. 7 illustrates very efficient flow paths, and to accommodate these, certain orientation changes have been made in the apparatus to accommodate the different flow paths.

Incoming commingled articles are conveyed in a commingled stream on a pit conveyor 11 to incline conveyor 21a, and onto belt conveyor 36a at residue presort station 22. Thereafter, an overhead magnetic belt 25a, like that described above, is used to remove ferrous containing material into bin 12a at station 24.

At station 24, the remaining commingled stream is turned 90 degrees onto screen 41a of screening station 26 which has a discharge 44a to a residue bin 13a. At the end of the screen 41a the stream is deflected again 90 degrees and introduced to the aluminum/plastic lift or sort station 28, which forms part of a closed loop air separation apparatus essentially like that described above. In this embodiment, however, the duct work defining the closed loop is extended, as will be described, to accommodate the somewhat different orientation of the entire system. It essentially

functions, however, in the same manner as in the previously described apparatus.

Turning now to the combined remaining glass articles not lifted upwardly at station 28, this glass is discharged onto a sort conveyor 71a, where it is manually sorted at station 30 into respective bins 15a, 16a and 18a as indicated. Mixed and broken glass is sorted into a mixed/broken bin as indicated.

From station 28, aluminum and plastic articles are lifted upwardly in a duct (not shown but corresponding to duct 55) forming a part of the closed loop air separation apparatus and are then conveyed horizontally in another duct (not shown but corresponding to duct 57) to a separator like that of the centrifugal or rotating separator shown in Fig. 3. This duct is disposed above conveyor 71a as shown in Fig. 7. The aluminum and plastic are then discharged from this separator to a grizzly scalper 90a (similar to scalper 90). This scalper discharges plastic articles onto a plastic conveyor 100a from where these articles can be sorted into a P.E.T. plastic bin and an H.D.P.E. plastic bin as illustrated.

Meanwhile, an eddy current non-ferrous metal separator conveyor apparatus 96a (like that of separator 96 of Fig. 3) is operable to discharge aluminum articles into a chute 120 for discharge into the aluminum bin as shown.

In the meantime, the closed loop air flow, separated from the plastic and aluminum articles, is returned to the general area of station 28 by an elongated duct (not

shown but corresponding in function to duct 60a) to a fan input (not shown). This fan has an output connected via ducts (not shown but corresponding in function to ducts 61, 52) to station 28 to blow upwardly and lift aluminum and plastic articles from the commingled stream, all as noted above, in a closed loop system. Accordingly, this alternative layout envisions a different disposition of the components described previously in this application, with extended duct work utilized to provide efficient flow paths and efficient component location.

Of course, flow rates and pressures in the closed loop described are controlled to provide the separation, conveying, dust skimming,and article flow rates and functions desired, such as described with respect to the apparatus of Figs. 1-6. Very efficient through puts, together with an efficient usage of facility floor space are thus provided.

IMPROVED AIR SEPARATOR

A preferred embodiment of the improved air separator is illustrated at 130 in Fig. 8. It will be appreciated that this separator may be utilized, for example, in place of the separator 59 as shown in Fig. 2, and is operable for receiving the fast-moving aluminum and plastic articles which have been lifted in the air column of the closed loop air stream, away from glass and heavier articles on the plate 54 at station 28.

The separator 130 is particularly useful where the commingled air stream, in addition to the articles noted

above, originally includes other extraneous and relatively lightweight articles of paper and plastic, for example. Such extraneous articles might include paper labels, for example, and such plastic articles might include, for example, lightweight plastic bags or films. All these can be entrained in the air stream and may agglomerate on the screens of the previously described two separators 59. These articles are difficult to remove therefrom, and clog the screen, reducing its efficiency. Where such commingled streams include a relatively large percentage of lightweight paper, plastic or other foreign objects which have not been previously removed, it is thus desirable to increase the efficiency of the flow through of the entire system. The separator 130 is particularly useful in that regard when compared, for example, to the separators 59, disclosed above.

Accordingly, it will be appreciated that the separator 130 is utilized in the closed loop downstream of the aluminum and plastic sort station 28 for separating aluminum and plastic articles lifted from the glass at station 28 from the closed loop air stream, and also for separating any lighter materials which have been entrained in that air stream. The separator in particular is connected to the upper end of the duct 55a, which converges from station 28 and defines an upwardly moving stream 56a of air conveying plastic and aluminum articles therein.

As shown in Fig. 8, the separator 130 is operatively connected to the stream 56a via the conduit 131 and

includes an inlet conduit or duct 132, having an upstream end 133 and a downstream or discharge end opening at 134 as shown in Fig. 8 into an enlarged chamber 135.

Chamber 135 includes tapering walls, such as at 136 and 137, which converge towards an outlet 138, operatively connected to an air lock 62a, which is identical to the air lock 62 previously described in this application. Chamber 135 may have relatively planar walls, tapering as shown in Fig. 8, or it may be of circular configuration, terminating in a cone, opening downwardly into the air lock 62a. Also, it will be appreciated that chamber 135 has a cross-section larger than effective duct opening 134.

An enlarged exhaust duct 140 communicates with chamber 135 at exit opening 141 and upper portion 142 of the exhaust duct tapers to a duct 143, of lesser diameter than the exhaust duct 140 and the tapered portion 142. Duct 143 has a discharge end 144, feeding into the vertical housing 145.

Vertical housing 145 extends downwardly to a receptacle 146. Housing 145 may comprise a rectangular or circular duct provided with an air lock section 147, defined by an upper door 148 and a lower door 149. Housing 145 also has an outlet opening 150 connected to a conduit 151, which functions similarly to conduit 60a of Fig. 2. That is to say that conduit 151 leads from the housing 145 back to the inlet of a fan or blower 51.

A porous air separation conveyor 155 comprises over two vertical runs, 156 and 157, deferred by means of

horizontally disposed pulleys 158 and 159, serving as head and tail stock for the conveyor 155. Pulleys or head stocks 158 and 159 are mounted on horizontal axes and are of such a width to extend substantially across the width of the housing 145. A porous belting material, such as a perforated or woven fabric belt or metal belt made with perforated slats, is formed in an endless loop about the pulleys 158 and 159, such that it is disposed in the downwardly extending run 156 and the upwardly moving or return run 157. This conveyor functions as a screening conveyor for the air stream as it moves away from the chamber 135 and through the ducts 142, 143 and across housing 145, on its way back to the inlet of the blower or fan.

The operation of this separator will now be described. It will be appreciated from Fig. 8 that separator 130 is disposed so as to receive the column 56a of air, entraining along with it plastic and aluminum articles which have been lifted upwardly from station 28 from any glass and any heavier articles at station 28. The lifted aluminum and plastic stream 56a might also include lighter materials such as paper, plastic film, plastic bags, etc., which are also lifted by the fast-moving air stream. As shown in Fig. 8, the fast-moving air stream is confined in the column or conduit 55a, which is a portion of the closed loop separation stream described previously in this application. The air stream moves through the curved duct 131 at a high rate of speed, which may be as high, in this particular

application and for example, as 4500 feet per minute. When the stream moves through the duct 131, it enters the upstream end of the duct 132 and moves through duct 132 into the chamber 135.

It should be appreciated that the duct 132 has a rear wall 139, against which the stream is directed. Materials in the stream will tend to engage this wall and then flow or move downwardly into the chamber 135.

Since the chamber 135 is of a substantial volume and cross-sectional area, as compared with the volume and cross-sectional area of the ducts 131 and 132, for example, the velocity of the air stream is significantly reduced as it enters the chamber 135 such that air exiting from the chamber 135 through the opening 141 into the exhaust ducts 140 and 142 may be reduced to, for example, as low as 800 fpm in velocity. The aluminum and plastic as indicated by the arrow so marked in Fig. 8 tends to fall out of this air stream and is guided by the cone of the chamber 135 or the tapered walls 136, 137, toward the opening 138 and into the air lock 62a. The aluminum and plastic is thus handled by the air lock for further separation, as described previously in this application.

The air stream, at this point of relatively low velocity, now moves upwardly through the ducts 140 and 142 to the concentrated duct 143, where the velocity is again increased and may be on the order of approximately 1500 to 2000 fpm. The duct 143 directs the flowing air stream at this now increased velocity to the exhaust end 144, where

the air stream is directed into the housing 145 and toward the porous conveyor 155. When the air stream hits the conveyor, the air tends to move through the porous material of the conveyor belting, through the housing 145, and through the opening 150, to the conduit 51, from where the air stream is returned to the blower 51, where recirculation as part of the closed loop separation system.

Porous conveyor 155 is operable to remove from the air stream, lighter weight materials which may not have fallen out of the air stream in the chamber 135. These may include, for example, paper articles or lightweight plastic articles such as plastic film, labels, plastic bags, etc. These articles engage the porous belting in the downwardly moving run 156 of the conveyor 155, where they are conveyed downwardly toward the lower end 161 of housing 145. Since the lower end 161 of housing 145 is shut off by door 148, there is relatively no air movement in the lower end 161 and articles reaching the end of the conveying run 156 will tend to fall off the conveyor into the lower end 161 of the housing 145. To this end, the pulley 159 may be a solid pulley, so that there is relatively no air flowing through the porous conveyor web at that point, to facilitate the dropping off of lightweight articles therefrom.

In addition, a scraper 162 may be positioned within the housing 145 on the upwardly moving or return run 157 of the conveyor. Scraper 162 may have one or more flexible rubber strips 163, for example, disposed in sliding engagement with the conveyor run 157, for scraping off any

material which still resides thereon. As well, scraper 162 forms an obstruction to prevent any material from moving upwardly in the housing 145 to the opening 150 and duct 151. Since the conveyor 155 extends across the housing and since the upper tail stock 158 is located very near a housing wall, the undesired materials of lighter weight which are entrained in the air stream at this point, are removed from the air stream, and are obstructed from access to opening 150.

Once the materials have fallen into the lower end 161 of the housing 145, they fall onto the sliding door 148. This door may be selectively opened by sliding transversely to permit materials in the duct or lower end 161 of the housing 145 to fall beneath the door 148. Thereafter, the door 148 can be closed and the door 149 slid open to permit the materials in the air lock section 147 to fall into the receptacle 146.

Accordingly, the separator 130 provides an advantageous means by which materials are purged from the closed loop air stream, which is then returned to the fan for reintroduction to the station 28 at high velocity to lift still further plastic and aluminum articles from glass and heavier articles at the station 28. The aluminum and plastic articles so lifted are deposited via chamber 135 to air lock 62a, from where they are further separated as previously disclosed in this application. The remaining lighter weight materials which do not drop out of the air stream within chamber 135, are effectively removed by the

conveyor 155 and deposited in the receptacle 146. Since the conveyor 155 has a lower end disposed in a housing where there is relatively little, if any, air movement, lighter weight materials collected on the conveyor 155 are prone to fall off and are thus efficiently separated from the air stream.

ALTERNATIVE EMBODIMENTS OF AIR SEPARATOR

Figs. 9-11 illustratively disclose alternative embodiments of the separator of Fig. 8. Turning first to Fig. 9, separator 170 includes an inlet duct 171, having a discharge end opening 172, through which an air stream entraining aluminum and plastic articles lifted from a separation station 28 (not shown), are conveyed at high velocity by means of a closed loop portion of an air stream into an enlarged chamber 173. Chamber 173 is of larger cross-sectional area than the duct opening 172. A separation conveyor 174 is disposed horizontally about head stock and tail stock 175, 176, conveyor 174 having an upstream run 177 moving in the direction as shown by the arrow A in Fig. 9, and a downstream or return run 178 moving in the direction of the arrow B as shown in Fig. 9. The conveyor 174 is disposed in a cross exhaust duct 179, so as to form a closure across the mouth 180 of the duct 179. A seal (not shown) can be used at the right hand end of the conveyor to positively seal off duct 179 and insure all air flowing into it goes through the conveyor. Duct 179 is operatively connected to the blower 51 for closing the closed loop air stream and for directing the purged air

stream into the blower inlet and thence into the station 28 for separation purposes.

The conveyor 174 includes a porous conveyor web as described with respect to the conveyor 155 in Fig. 8. An opening 181 is disposed in the duct 179 on the upstream side of the conveyor 174 and an enlarged chamber 182 is disposed on the other side of the opening for receiving paper and scrap material from the conveyor 174. Chamber 182 leads to a depending conduit 183 for receiving paper, plastic or other scrap materials onto sliding door 184 which, together with door 185, defines an air lock 186 for the removal of paper and plastic materials into receptacle 187, in the same fashion as described with respect to the apparatus of Fig. 8.

It will be appreciated as the high velocity stream 56a is admitted into the chamber 173 through the opening 172, the greater cross-sectional area of the chamber causes a pressure drop and substantially reduces the velocity of the air flow. Some of the air flow and articles engage back wall 188. Since the velocity of the air stream is substantially reduced, plastic and aluminum articles can fall out to the air lock 62a, while the air stream then moves upwardly through the porous conveyor 174 and into duct 179. Any lighter weight material such as paper or plastic, for example, which are still entrained in the moving air stream, engage the conveyor 174 and are conveyed to the left, or in the direction of arrow A. Once these materials pass the opening 181, they reside within the chamber 182, in which

there is relatively no air flow due to the increased chamber size and the fact it has no open flow outlet. The materials thus drop off the conveyor 174 and into the chamber 182 for collection in receptacle 187. A scraper 189, like scraper 162, may be provided, as shown in Fig. 9, for the purpose of finally scraping off from the conveyor 174 any material remaining thereon.

Another alternative embodiment is disclosed in Fig. 10. In this particular embodiment, a separator 195 comprises an entry duct 196, having a duct opening 197, into an enlarged chamber 198, having tapering or conical walls converging to a discharge opening 199 into an air lock 62a. The chamber 198 is of larger cross-sectional area than duct opening 197, such that the moving column of air, plastic and aluminum materials entering the chamber experience a pressure drop and reduce in velocity to permit the aluminum and plastic materials to fall out to the air lock 62a. The air them moves upwardly through the tapering portion 200 to the duct 201, where it is conveyed to or toward the separation conveyor 202. Separation conveyor 202 comprises head stock 203 and tail stock 204, about which is wrapped a porous conveying web or belt into run 205 and return run 206. Conveyor 202 is disposed across an inlet opening 207 of duct 208, so that duct 208 is closed off with the exception of air moving through the conveyor 202. A seal (not shown) may be provided between the conveyor end and duct wall.

The conveyor extends vertically and downwardly into a chamber 209, in which there is relatively little

moving air flow and which is preceded by a diverging chamber 210. At diverging chamber 210, the air stream loses further velocity from that velocity it had in duct 201 and moves onto the conveyor 202 and thereafter into the duct 208. Any lighter weight materials still entrained in the air stream at this point engage the run 205 of the conveyor 202 and move downwardly as viewed in Fig. 10, into the duct or chamber 209, where there is relatively little air flow. Duct 209 is provided with a lower end 211 and sliding doors 212, 213, which form an air lock 214, for disposal of the materials removed from the air stream, into the receptacle 215, as described in connection with the preceding embodiments.

Accordingly, it will be appreciated that aluminum and plastic articles are removed from the air stream 56a by virtue of the reduced air stream velocity, which is generated by the entry of the air stream into the enlarged chamber 198. From there, the air stream is again concentrated in the tapering duct 200 into duct 201, from where the air stream is conveyed to duct 208, which leads to the inlet of a blower 51. The air stream, however, must pass through the porous conveyor 202 and any material still entrained in the air stream, such as paper, plastic film, bags or the like, engage the conveyor 202 and are dropped out into the chamber 211 for collection in receptacle 215.

Turning now to Fig. 11, a further alternative embodiment is disclosed, where separator 220 is shown. Separator 220 is operatively connected to separation station

28 via an inlet duct 221, having a discharge opening or duct 222. The separator 220 includes an enlarged chamber 223, formed by tapering or conical walls 224, 225, converging to a discharge opening 226. Chamber 220 further has an outlet opening 227, leading into a duct 228, which is connected to the inlet of a blower 51 (not shown). The discharge outlet 226 is operatively connected to an air lock 62a, as previously described in this application. Chamber 223 is larger in cross-section than duct opening 222.

In this particular embodiment, it will be appreciated that a porous conveyor is not utilized. Instead, a high velocity column 56a of air entraining therein plastic and aluminum lifted off of glass and heavier articles at station 28, is introduced through the opening 222 into the enlarged chamber 223. By virtue of the enlargement of chamber 223, the air stream undergoes a pressure drop which significantly decreases the velocity of the air stream and entrained articles and permits materials entrained therein to drop out through opening 226 to the air lock 62a, from where they can be removed from the air stream and further separated.

This particular embodiment, as shown in Fig. 11, is particularly useful where there is a relatively minimal amount of residual lightweight articles expected in the commingled stream which is handled in the entire separation system. In this regard, such prepared commingled streams may not embody any lightweight paper or plastic bags or the like, which require a particular porous-like conveyor or

some sort of other mechanical screen across the air stream. Accordingly, it has been found that in some systems, and depending on the nature of the commingled stream to be separated, it is only necessary to provide an air separator for dropping out the relatively lightweight aluminum and plastic articles from the commingled air stream, and that without further screening, the air stream may be then returned to the inlet of the blower 51 in the closed loop system.

In each embodiment illustrated in Figs. 8-11, it will be appreciated that the respective enlarged chamber 135, 173, 198 and 223 are of larger cross-section than the effective duct openings feeding into them so the velocity of the closed loop air stream flowing into them is reduced. Each chamber has an air exhaust outlet or duct, preferably of smaller cross-section than the chamber to reconcentrate the air stream and forming an exhaust passage for the stream. In the embodiments of Figs. 8, 9 and 10, the exhaust passages are directed onto the porous conveyors noted for transporting remaining articles thereon away from the closed loop air stream, thus purging it with a continuously fresh, unobstructed effective screen surface.

In the embodiments of Figs. 8 and 10, the exhaust passage has a horizontally oriented portion where the conveyor belt is vertically oriented. In the Fig. 9 embodiment, the exhaust passage is vertically oriented and the conveyor belt is horizontally oriented.

In the Fig. 8, 9 and 10 embodiments, the end of the conveyor extends into a closed or substantially still air chamber which is generally free of any significant air flow, to the extend that articles are free to drop from the conveyor toward the discharging housing between the air lock doors without being blown back into the air stream or held on the conveyor by a pressure differential. Also, it will be appreciated in these embodiments that the respective exhaust passages are open to the closed chambers upstream of the conveyor so the articles can be transferred into the chambers for collection.

Moreover, and as elsewhere noted, the conveyors can be sealed at one or both ends of the walls of the passages or housings as suggested by the drawings, or are otherwise spaced closely enough thereto so articles do not flow past the screening area and back to the inlet of the blower 51.

It will also be appreciated that the moving conveyor screen of embodiments in Figs. 8-10 can be a porous web belt conveyor as shown or any other type of moving screen or pourous surface, having a portion in the exhaust passage and a portion spaced away therefrom, so the screen moves through the exhaust passage to collect articles and then away therefrom to discharge the articles from the screen away from the air straem.

Finally, it will be appreciated that the air locks associated with the closed chambers of the embodiments of Figs. 8-10 comprise discharge housings or chambers connected

to outlets from the closed chambers by means of first or upper doors, and further include lower doors for opening the discharge chambers when the upper doors are closed for collection of the purged articles.

Accordingly, it will be appreciated that the various embodiments shown in Figs. 8-11 can be utilized in a separation system as described above for the separation of aluminum and plastic articles and other articles from the closed loop air stream, which is utilized to separate relatively lightweight plastic and aluminum articles from glass and other heavier articles at a separation station 28, for example, as described above. The flow through and efficiency of the embodiments shown in Figs. 8-11 is particularly desirable and helpful where extraneous lightweight materials which must be separated from the air stream, are expected in a commingled stream, such as with the embodiments of Figs. 8, 9 and 10 or where relatively little extraneous material is expected, wherein the embodiment shown in Fig. 11 can be effectively utilized. In any case, the embodiment shown in Fig. 11 will eliminate the various screens shown in all of the figures, where the embodiments of 8, 9 and 10 serve more efficiently to purge the air stream of very lightweight materials such as paper and plastic film and the like, without clogging any screens and requiring cleaning or downtime.

These and other modifications and advantages will become readily apparent to those of ordinary skill in the art without departing from the scope of the invention and applicant intends to be bound only by the claims appended hereto.

WE CLAIM:

1. Apparatus for separating articles entrained in an air stream from such stream, said apparatus comprising:

first means for separating heavier articles from said stream;

said first means comprising an enlarged chamber connected to a duct opening for delivering such stream and articles thereto;

said chamber having a larger cross-section than said duct opening for reducing the velocity of such stream wherein articles entrained in said stream can be dropped out of said moving stream to purge said air stream therefrom; and

means for removing said dropped out articles from said chamber;

wherein said chamber has an exhaust passage extending therefrom for receiving said air stream therefrom and further including second means for further purging said stream of lighter articles entrained therein, said second means including:

a moving conveyor extending across said exhaust passage;

said moving conveyor comprising a moving porous surface extending across said passage, such that said stream

can pass therethrough, with said surface blocking articles in said stream;

a closed chamber operatively open to said exhaust passage at least upstream of said conveyor;

said conveyor surface having a portion extending into said closed chamber away from said exhaust passage for dropping articles therefrom, into said closed chamber.

2. Apparatus as in claim 1 wherein said air stream comprises a closed loop air stream passing through a commingled stream of aluminum, plastic and glass articles for lifting aluminum and plastic articles vertically away from said glass articles at a location upstream in said loop from said first means for separating heavier articles from said stream.

3. Apparatus as in claim 2 further including a scraper means for wiping articles on said surface away therefrom and into said closed chamber.

4. Apparatus as in claim 2 wherein said exhaust passage includes a horizontally oriented portion and said conveyor surface has a vertically oriented run extending across said horizontally disposed passage.

5. Apparatus as in claim 2 wherein said exhaust passage includes a vertically oriented portion and said conveyor surface has a horizontally oriented run extending across said vertically oriented passage.

6. Apparatus as in claim 5 wherein said closed chamber includes an area greater in cross-section than said exhaust passage, and wherein the portion of said conveyor disposed in a closed chamber resides proximate said enlarged area thereof.

7. Apparatus as in claim 2 further including means for removing such articles from closed chamber while retaining the chamber effectively closed.

8. Apparatus as in claim 7 wherein said removing means includes a discharge chamber beneath said closed chamber, an upper door selectively closing said closed chamber from said discharge chamber;

an article outlet from said discharge chamber, and

a lower door selectively closing said discharge chamber from said closed chamber,

wherein said articles are collected on said first door, dropped into said discharge chamber onto said lower door, upon opening of said upper door, and dropped through said article outlet upon opening of said lower door while said upper door is in closed position.

9. Apparatus for separating aluminum, plastic and glass articles from a commingled stream of such articles including:

means for generating and defining a closed loop of moving air, a portion of which loop is directed vertically upward;

means for introducing articles in said commingled stream to and across said vertically upward moving air, wherein said air lifts plastic and aluminum articles away from glass articles;

means for receiving aluminum and plastic articles lifted in said closed loop from said stream, and for separating said aluminum and plastic articles from said loop;

means for receiving glass articles not lifted from said stream; and

means for separating said lifted aluminum from lifted plastic articles received from said closed loop wherein said aluminum and plastic article receiving and separating means includes:

first means for separating heavier articles from said closed loop stream;

said first means comprising an enlarged chamber connected to a duct opening for delivering such stream and articles thereto;

said chamber having a larger cross-section than said duct opening for reducing the velocity of such stream wherein articles entrained in said stream can be dropped out of said moving stream to purge said air stream therefrom; and

means for removing said dropped out articles from said chamber.

10. Apparatus as in claim 9 wherein said chamber has an exhaust passage extending therefrom for receiving said air stream therefrom and further including second means for further purging said stream of lighter articles entrained therein, said second means including:

a belt conveyor extending across said exhaust passage;

said belt conveyor comprising a moving porous web extending across said passage, such that said stream can pass therethrough, with said belt blocking articles in said stream;

a closed chamber operatively open to said exhaust passage at least upstream of said conveyor;

said belt conveyor having a portion extending into said closed chamber away from said exhaust passage for dropping articles therefrom, into said closed chamber.

11. Apparatus as in claim 10 wherein said exhaust passage includes a horizontally oriented portion and said conveyor belt has a vertically oriented run extending across said horizontally disposed passage.

12. Apparatus as in claim 10 wherein said exhaust passage includes a vertically oriented portion and said conveyor belt has a horizontally oriented run extending across said vertically oriented passage.

13. Apparatus as in claim 12 wherein said closed chamber includes an area greater in cross-section than said exhaust passage, and wherein the end of said conveyor disposed in a closed chamber resides proximate said enlarged area thereof.

14. Apparatus as in claim 10 further including means for removing such articles from closed chamber while retaining the chamber effectively closed.

15. Apparatus as in claim 14 wherein said removing means includes a discharge chamber beneath said closed chamber, an upper door selectively closing said closed chamber from said discharge chamber;

an article outlet from said discharge chamber; and

a lower door selectively closing said discharge chamber from said closed chamber, wherein said articles are collected on said first door, dropped into said discharge chamber, upon opening of said upper door, onto said lower door, and dropped through said article outlet upon opening of said lower door while said upper door is in closed position.

16. A closed air loop separator for separating plastic and aluminum articles from glass articles, said separator comprising:

means for establishing an upwardly moving column of air, comprising a portion of said loop, across a moving stream of commingled plastic, aluminum and glass articles, and for lifting said plastic and aluminum articles in said air column upwardly and away from moving glass articles; and

means for discharging said lifted plastic and aluminum articles from said closed air loop separately from said glass articles, said discharging means comprising:

first means for separating heavier articles from said stream;

said first means comprising an enlarged chamber connected to a duct opening for delivering such stream and articles thereto;

said chamber having a larger cross-section than said duct opening for reducing the velocity of such stream wherein articles entrained in said stream can be dropped out of said moving stream to purge said air stream therefrom; and

means for removing said dropped out articles from said chamber.

17. Apparatus as in claim 16 wherein said chamber has an exhaust passage extending therefrom for receiving said air stream therefrom and further including second means for further purging said stream of lighter articles entrained therein, said second means including:

a belt conveyor extending across said exhaust passage;

said belt conveyor comprising a moving porous web extending across said passage, such that said stream can pass therethrougn, with said belt blocking articles in said stream;

a closed chamber operatively open to said exhaust passage at least upstream of said conveyor;

said belt conveyor having a portion extending into said closed chamber away from said exhaust passage for dropping articles therefrom, into said closed chamber.

18. A closed air loop separator for separating plastic and aluminum articles from glass articles, said separator comprising:

means for establishing an upwardly moving column of air, comprising a portion of said loop, across a moving stream of commingled plastic, aluminum and glass articles, and for lifting said plastic and aluminum articles in said air column upwardly and away from moving glass articles; and

means for discharging said lifted plastic and aluminum articles from said closed air loop separately from said glass articles;

wherein said separator further comprises:

air fan means;

a porous surface for receiving said stream of commingled articles;

first air duct means operably extending from said air fan means to a plenum beneath said porous surface and conveying a flow of air therethrough;

second air duct means extending upwardly from said porous surface and defining an upwardly extending column of flowing air carrying plastic and aluminum articles lifted from said commingled stream by air flowing through said porous surface;

a separator means for separating plastic and aluminum articles from said closed air loop;

third air duct means connecting said second air duct means and said flowing air column to said separator means;

said separator means having an air outlet operably connected to an air intake of said air fan means and an air lock means for discharging plastic and aluminum articles from said closed air loop; and

means for receiving glass articles moving from said porous surface out of said closed air loop;

and wherein said discharging means comprises:

first means for separating heavier articles from said stream;

said first means comprising an enlarged chamber connected to a duct opening for delivering such stream and articles thereto;

said chamber having a larger cross-section than said duct opening for reducing the velocity of such stream wherein articles entrained in said stream can be dropped out of said moving stream to purge said air stream therefrom; and

means for removing said dropped out articles from said chamber;

wherein said enlarged chamber has an exhaust passage extending therefrom for receiving said air stream therefrom; and

second means for further purging said stream of lighter articles entrained therein, said second means including:

a belt conveyor extending across said exhaust passage;

said belt conveyor comprising a moving porous web extending across said passage, such that said stream can pass therethrougn, with said belt blocking articles in said stream;

a closed chamber operatively open to said exhaust passage at least upstream of said conveyor;

said belt conveyor having a portion extending into said closed chamber away from said exhaust passage for dropping articles therefrom, into said closed chamber.

19. A closed air loop separator for separating plastic and aluminum articles from glass articles, said separator comprising:

means for establishing an upwardly moving column of air, comprising a portion of said loop, across a moving stream of commingled plastic, aluminum and glass articles, and for lifting said plastic and aluminum articles in said air column upwardly and away from moving glass articles; and

means for discharging said lifted plastic and aluminum articles from said closed air loop separately from said glass articles, said discharging means comprising:

first means for separating heavier articles from said stream;

said first means comprising an enlarged chamber connected to a duct opening for delivering such stream and articles thereto;

said chamber having a larger cross-section than said duct opening for reducing the velocity of such stream wherein articles entrained in said stream can be dropped out of said moving stream to purge said air stream therefrom; and

means for removing said dropped out articles from said chamber,

wherein said chamber has an exhaust passage extending therefrom for receiving said air stream therefrom

and further including second means for further purging said stream of lighter articles entrained therein, said second means including:

a moving conveyor extending across said exhaust passage;

said moving conveyor comprising a moving surface extending across said passage, such that said stream can pass therethrougn, with said surface blocking articles in said stream;

a closed chamber operatively open to said exhaust passage at least upstream of said conveyor;

said conveyor surface having a portion extending into said closed chamber away from said exhaust passage for dropping articles therefrom, into said closed chamber.

20. A method of separating aluminum and plastic articles from a closed loop moving air stream entraining such articles, said method comprising the steps of:

introducing said air stream and articles therein from a first passage of one effective cross section to a second passage of greater effective cross section, thereby reducing velocity of said air stream and articles therein;

collecting articles dropping out of said air stream; and

further purging said air stream of any other articles remaining therein downstream of said second passage.

21. A method as in claim 20 comprising the further purging steps of:

concentrating said air stream downstream of said second passage;

directing said concentrated air stream onto a porous conveyor web, said air straem moving therethrough in said closed loop,

collecting articles remaining in said air stream on said conveyor,

transporting said collected articles out of said air stream for removal from said closed loop.

22. A method as in claim 20 comprising the further steps of:

dropping said collected articles from said conveyor into a substantially still air chamber maintained outside said air stream.

23. A method as in claim 21 including the further steps of:

dropping said collected articles into an air lock and removing said articles from said still air chamber through said air lock.

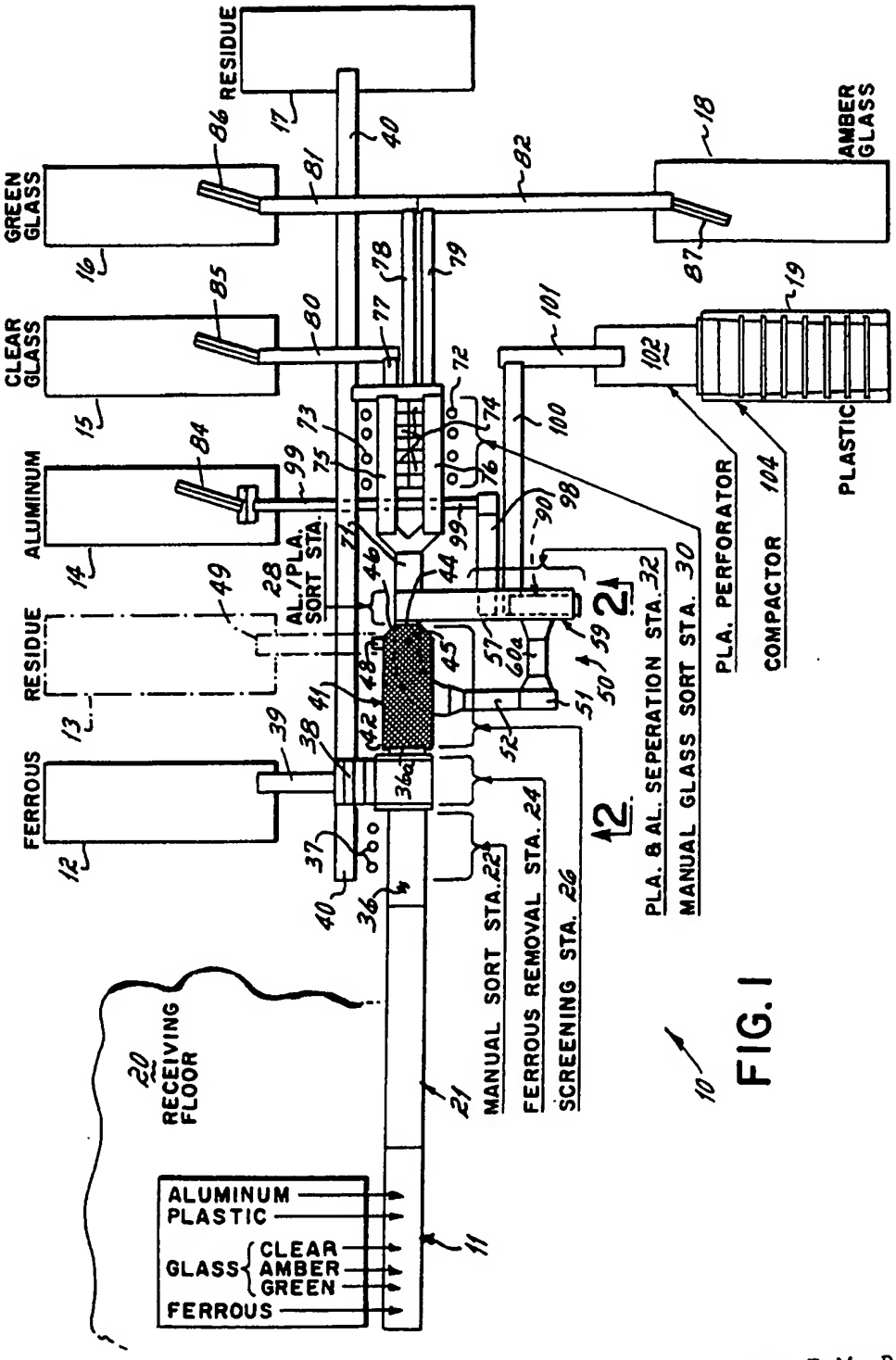

FIG. 1

Alex. E. MacRae & Co